Temperature Impairment: Dams, Model Analysis & Temperature Criteria Interpretation –

Brief Overview of Pend Oreille TMDL Issues

Objectives

This document provides an update on the temperature TMDL for the Pend Oreille River in Washington State, and includes general background on temperature issues in the West, an overview of the Pend Oreille area, and a specific discussion of concerns raised by the Kalispel Tribe.

Issue

The Washington State Department of Ecology has submitted a TMDL for temperature in the Pend Oreille River to Region 10 for approval. Region 10 has agreed not to approve this TMDL until it has completed consultation with the Kalispel Tribe. Specifically, the Tribe disagrees with Ecology's method of analyzing model data in the TMDL because they believe:

- The State's method masks the frequency and magnitude of violations of both State and Tribal water quality standards;
- The pooling period used by the State as a part of this method is arbitrary and does not correctly evaluate for exceedences of the State's own daily maximum criteria;
- The Tribe's preferred method is more precise and necessary to ensure that Tribal standards are met; the use of any other method violates the requirement that TMDLs meet downstream state standards and the Tribe's sovereign right "to determine impairment of its own water quality standards."

The Tribe thus argues that this TMDL must be disapproved and revised using its preferred method of data evaluation. Region 10 does not see a basis for disapproving the TMDL. The Tribe's attorney sent a letter to Region 10 reiterating their concerns and requesting an impartial review by other EPA staff. This paper provides background for that review.

Typical Issues associated with Temperature Impairment

Water quality standards for temperature in Western states are typically designed to protect cold water salmonid species. These species spawn in the spring and fall. Cool water temperatures are required for the young to survive. Many states in the West have adopted seasonal temperature criteria which include lower numeric criteria for the fall, winter and spring to protect juvenile salmonids during egg incubation and rearing. Summer criteria are typically higher, set at a temperature that is protective of adult salmonids. There is generally a narrative clause in the temperature standards for instances where natural conditions exceed the numeric criteria. TMDLs in the region have documented that natural conditions are generally warmer than the numeric criteria in larger streams and rivers. Natural conditions are determined by modeling or use of upstream data or reference site conditions.

Anthropogenic causes of temperature impairment include:

- Loss of stream side vegetation and shade due to timber harvest, agricultural practices or development
- Loss of stream flow due to water withdrawals
- Stream widening caused by increased sediment and decreased stream stability
- Point source discharges
- Temperature increases in impounded waters behind dams

Temperature effects of dams in streams are variable. Some dams cause temperature increases throughout the summer and others are designed, retrofitted or managed to lower temperatures and benefit cool water species during the summer. The major temperature issue related to dams in Region 10 is called "temperature shift". Even dams that release cooler than natural water throughout the summer months can end up in the late summer and fall with very warm reservoirs. When the fall season rains come and cool water begins to flow down from the mountains these cool flows get stalled in the reservoirs, and mix with the warm water there. In a stream without a dam, water temperatures would cool more rapidly and dramatically during this season. Temperature shift can result in fall season temperatures several degrees warmer than would occur in the same stream without a dam. Often this effect persists over many weeks and may negatively affect salmon that spawn in the fall.

Temperature Issues in the Pend Oreille River

The Pend Oreille River is the second largest tributary to the Columbia River. It begins at the outlet to Lake Pend Oreille, a 148 square mile lake in northern Idaho. Upstream of this lake the river is called the Clark Fork and its watershed includes most of western Montana. The U.S. portion of the Pend Oreille River has three dams. Albeni Falls dam is situated in Idaho just below the lake and just upstream of the Washington State border. Box Canyon and Boundary dams are in Washington State. Boundary Dam is just upstream of the international border with Canada (see map on p.18 of TMDL).

Water Quality Criteria

The applicable Washington State temperature criteria for the Pend Oreille River are:

> Part 1: Temperature shall not exceed a 1-day maximum (1-DMax) of 20°C due to human activities. When natural conditions exceed a 1-DMax of 20°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C;
>
> Part 2: Nor shall such temperature increases, at any time, exceed $t = 34/(T + 9)$ where:
> *t = the allowable temperature increase; and*
> *T = the background temperature measured at a point unaffected by the discharges. The Pend Oreille River is affected by discharges from dams in both Washington and Idaho, so the modeled natural condition, which represents the unaffected river, is used to define T in this TMDL.*

The Kalispel Temperature Criteria for the river are:

> 7-day average of the daily maximum (7-DADMax) of 18°C.

1-day maximum (1-DMax) of 20.5°C.

For all designated uses, if natural conditions are above criteria then human influences can raise water temperatures by no more than 0.3°C.

Temperature issues in the Pend Oreille River

The Pend Oreille River was listed as impaired because it often exceeds 20°C daily in the summer. The river was modeled to determine the extent to which these exceedences were due to natural conditions or human activities. There are no anadromous (ocean migrating) salmonids in the Pend Oreille River. The species of concern there is bull trout (also called char), which spawns in the tributaries and is listed as threatened under the ESA. Bull trout require even colder water than other salmonids.

Modeling of the river for the TMDL showed that dams are the only significant anthropogenic causes of increased water temperature. The river is too wide and has too great a volume of water for shade along its banks or its tributaries' banks to have a noticeable effect on it. The few point sources discharging to the river do not affect temperature because their discharge flows were small in comparison to the river flow.

Temperature impairments in the Pend Oreille River are smaller and more subtle than those found in other dammed rivers in Region 10. When Region 10 modeled the river as part of the Columbia River TMDL, the one dimensional model showed no impairment. Two dimensional modeling of the river for the TMDL does not show the dramatic "temperature shift" issues, encountered in other dammed rivers in the region.[1] Model results did indicate that the Boundary and Box Canyon reservoirs cause increases in water temperatures in the upper levels of the water column. This type of surface temperature increase is often associated with dam impoundments because they widen the stream, exposing more water to solar input and they slow the flow of water through this widened area, both increasing the length of exposure to solar radiation and reducing turbulence and mixing. No previous Region 10 TMDL has addressed temperature impairment only occurring in the upper levels of the water column.

The TMDL model results show no temperature increase above natural conditions at the Idaho-Washington border. Rather the model showed that Albeni Falls dam in Idaho has a cooling effect on downstream water temperatures in the river. The outlet of Lake Pend Oreille, just upstream of Albeni Falls dam, is wide and shallow, which results in warm river temperatures under natural conditions, especially in the low water season. Albeni Falls raises the elevation of the water across this outlet area, reducing water temperatures, by allowing deeper water to flow through the lake outlet, the reverse effect of a typical dam impoundment.

Analysis of Model Data

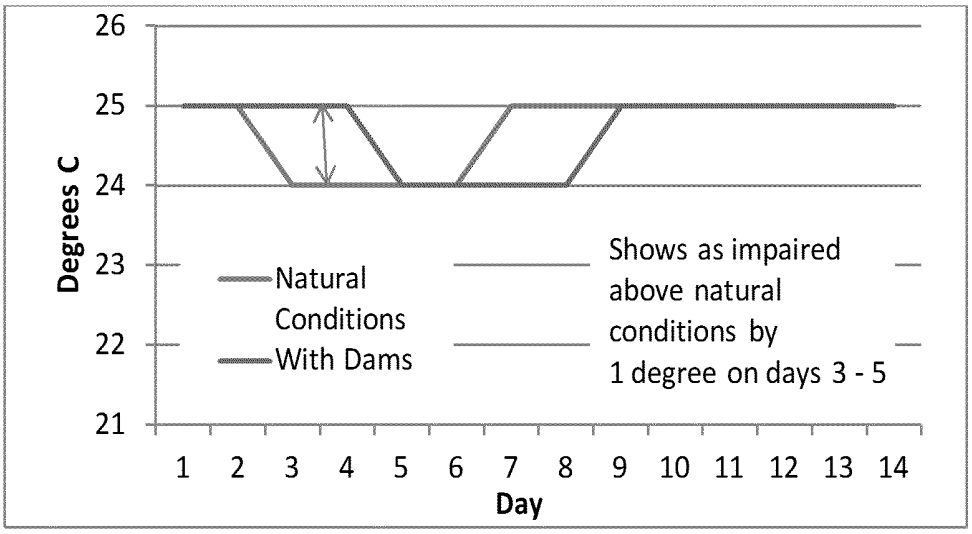
[1]See attached graphs at end of paper, which show comparisons of modeled natural conditions temperatures (dotted red lines) and current conditions for typical reaches.

The Pend Oreille River was modeled using CE-QUAL-W2, a two dimensional model. For the model, the 72 mile Washington portion of the river was divided into 448 segments, which were further divided by each one meter depth of river. These are the model cells. Temperatures were simulated on half-hour intervals for each cell for 2004 and 2005. The model results for current conditions were compared to data collected in the river in 2004 and 2005 and calibrated to fit that data. After calibration was completed the model was run for other scenarios than current conditions, including natural conditions, without the dams in place.

In 2007, an internal draft of the Pend Oreille River TMDL was reviewed by stakeholders. This draft TMDL used a "point by point" method of analyzing the model data to determine impairment and allocations for the TMDL. For example, to determine compliance with the one-day maximum criteria, the maximum data point from the current conditions model run for each day was compared to the same model cell and time data point from the natural conditions model run. If the current conditions model data point was higher than the natural conditions data point and exceeded 20°C, the difference between them was considered the magnitude of temperature impairment for that day. The 2007 draft TMDL set reductions based on the highest impairment shown on any day of the two-year model period.

This method of analysis generated many comments from the dam operators. One of the most compelling was presented by Battelle, Seattle City Light's consultant. They argued thatthat because dams alter the travel time of water downstream, a flush of cold water from a summer storm or cloudy day upstream would pass by the same location later in a dammed river than an undammed river. Because of this time lag, the point by point comparison - i.e., comparing natural and current conditions for the same time data point - would identify the difference as a temperature increase above natural conditions.

More specifically, when the cold water pulse passes through the natural conditions model run, the analogous cells of the current conditions run would not yet be cooled because of the lag time. In other words, the current condition cells would be warmer for that same specific time because the cold water pulse had not yet reached them. This difference would show up as a temperature increase using a point by point comparison. . The graph below attempts to illustrate this. Whether this offset "pulse" of cool water on a given day and location should be considered an increase or would have an adverse affect on cool water species is questionable.



To keep this type of background static from obscuring the magnitude of impairment from human activities, Ecology decided to use cumulative frequency analysis (CFA). This method of analysis was one of several analysis methods advocated by Seattle City Light in their comments.

CFA is a statistical analysis of two data sets, where the data distributions are compared at each rank percentile value. One cannot do a cumulative frequency analysis without first aggregating the data (selecting and pooling data from the model into a list of values) in some manner. This step should not be confused with "averaging the data", because CFA is a more robust comparison of the complete distribution of the data, not just the grand average of all the data.[2] CFA is a complex analysis method and it is not simple to understand how it works and its consequences.

Discussion of Kalispel Tribe Issues with TMDL Analysis

The State's method masks the frequency and magnitude of violations of both State and Tribal water quality standards

The Kalispel Tribe objects to Ecology's use of CFA analysis to determine temperature impairment and allocations in the river. They believe that this method of analysis hides the magnitude of impairment. The Tribe is particularly concerned that the TMDL does not show any violation of water quality standards at the Idaho/Washington border.

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[2] A more detailed description of CFA as used in the TMDL can be found on page 8.

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Detailed Description of Cumulative Frequency Analysis (CFA)

To analyze for exceedence of Washington's 20°C daily maximum and natural conditions criteria during the summer, Ecology applied the following methods. All the temperature output for both the existing and natural model runs, from every cell, was considered. Consistent with the water quality criteria, from these datasets, daily maximum temperatures were determined for each model segment for the entire study area. (The model divides the river based on segments and there are a number of cells for each segment based on water column depth.) For the existing condition daily maximum dataset, temperatures less than 20°C were excluded. This final existing dataset was then used to determine the natural dataset. The final natural condition daily maximum dataset was based on a one-to-one match, by day and segment, when existing condition daily maximum temperatures exceeded 20°C. This analysis process was directed toward answering the intent of the criteria.

When existing condition temperatures exceed 20°C what were the comparable temperatures that occurred naturally?

Are they now greater by 0.3°C, indicating an exceedance of the temperature criteria?

Further analysis was based on common grouping of the model segments into river reaches. From the existing and natural datasets, for each river reach, a cumulative frequency distribution was determined and plotted in a graph with temperature on the horizontal axis and cumulative percent exceedence (percentile) on the vertical axis. The two cumulative frequency distributions which result were then subtracted from each other to evaluate the criteria.

For each percentile, the current (exisiting) condition was subtracted from the natural condition resulting in a temperature differential. This temperature difference is plotted in a graph with the temperature differential between the two on the horizontal axis and the percentile again as the vertical axis. Any temperature differential exceeding the 0.3C above natural conditions allowed by the water quality standard (the vertical red line in the example graph below) was considered an impairment.

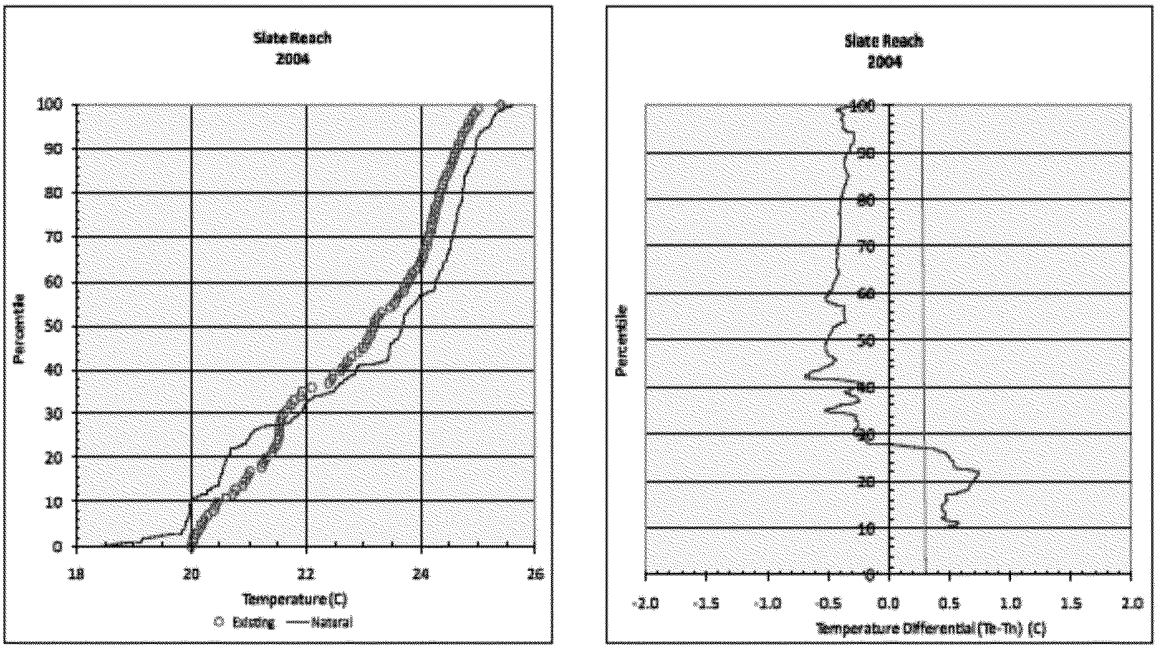

Figure 16. The cumulative frequency distribution of daily maximum temperatures and temperature differential for the Metaline and Slate reaches, 2004.

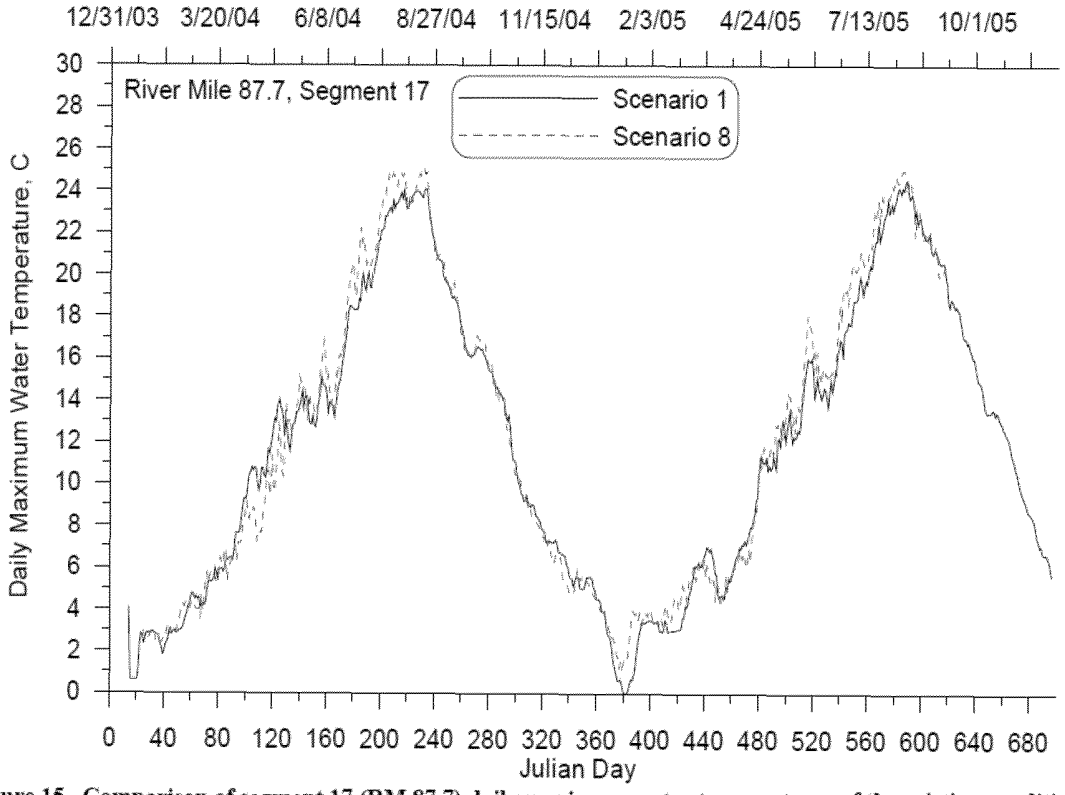

Figure 15. Comparison of segment 17 (RM 87.7) daily maximum water temperatures of the existing conditions scenario 1 and the natural conditions scenario 8.

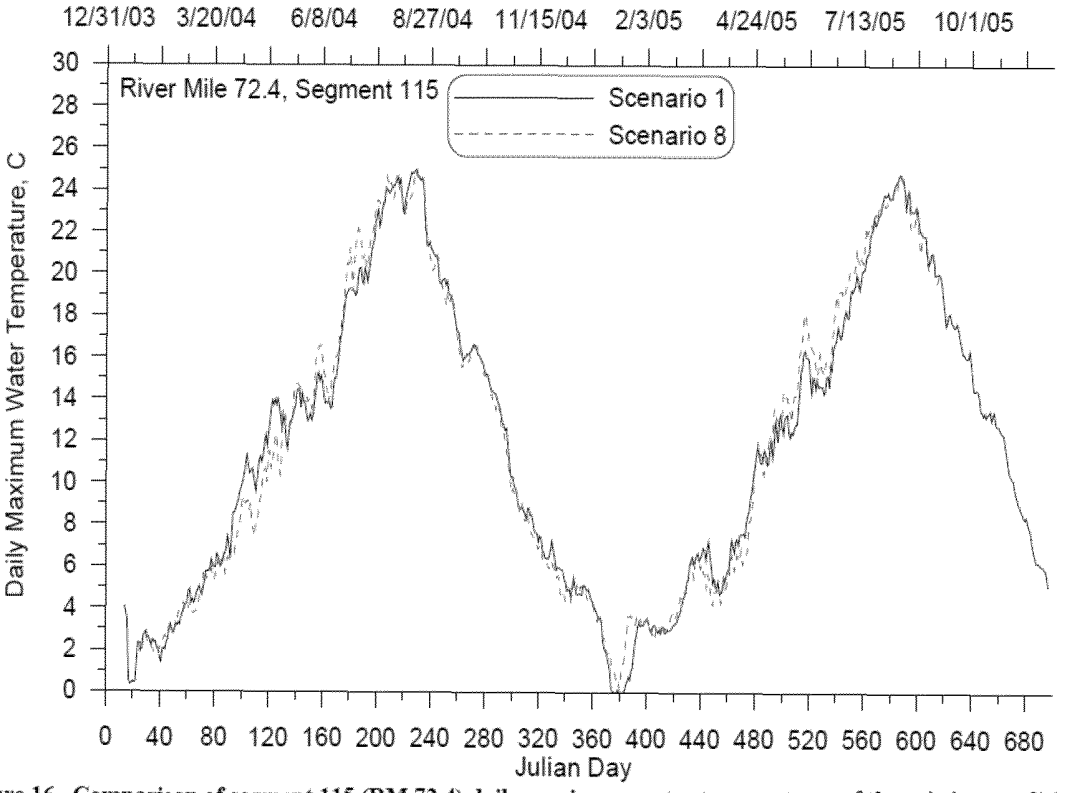

Figure 16. Comparison of segment 115 (RM 72.4) daily maximum water temperatures of the existing conditions scenario 1 and the natural conditions scenario 8.